

# Reflections on Test and Evaluation (T&E)

## T&E Infrastructure, Reengineering Army T&E, and Building a Viable Test Range Complex

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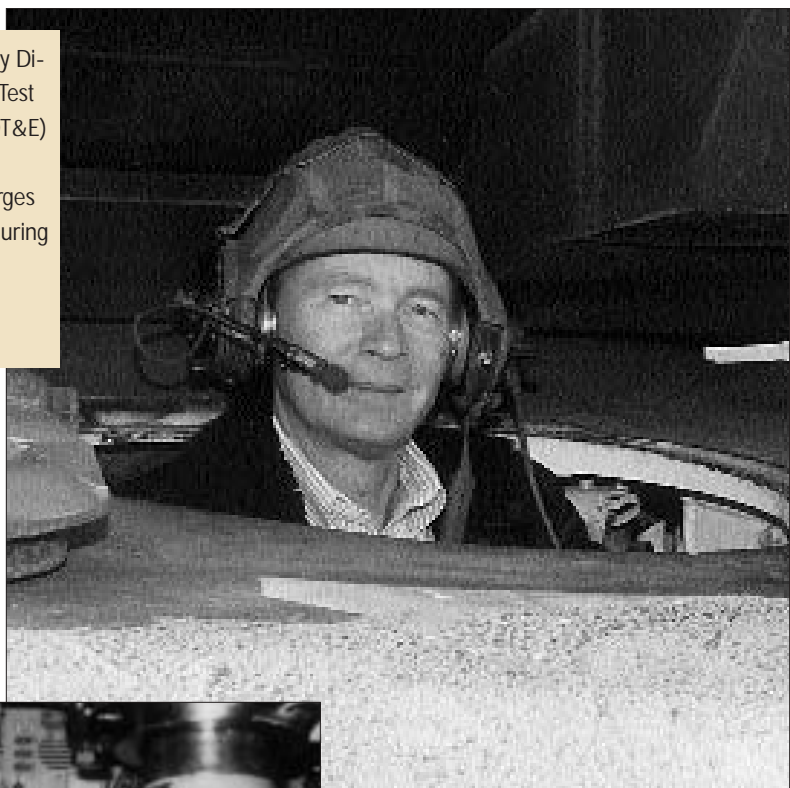
Having devoted a career to various aspects of Test and Evaluation (T&E) of Department of Defense weapon systems, we have enjoyed the good fortune of being able to work with many of the best and the brightest people in testing. Our experiences as testers, consultants, managers of test programs and facilities, and oversight of test ranges and programs have enabled us to interface with a large segment of the DoD T&E infrastructure. We have been fortunate to be involved in many studies on a multitude of T&E issues involving the best visionaries in government.

We could not emerge from the experiences and opportunities afforded by our lifelong careers as testers and evaluators without formulating several strong opinions concerning the direction of DoD T&E. In an effort to document several of these opinions and experiences, this article—the first of two entitled “Reflections on Test and Evaluation” covers three themes we have co-authored: State of the T&E Infrastructure, Lessons Learned in Reengineering Army T&E, and Critical Attributes for a Viable Test Range Complex.

### State of the T&E Infrastructure

The T&E infrastructure is best viewed and assessed in the context of a mix of people, processes, and facilities. The health of that infrastructure, as DoD enters the 21<sup>st</sup> century, is an essential ele-

John Gehrig, Deputy Director, Operational Test and Evaluation (DOT&E) for Resources and Ranges, OSD, emerges from a tank turret during M1A2 Testing, Aberdeen Proving Ground, Md., 1999.



Gehrig tests the periscope systems aboard the *USS Nevada* Trident Submarine in 1986. All systems of the submarine are tested between missions.

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swer crucial questions on system performance, operational effectiveness, suitability, and survivability. T&E facilities must be up to the challenge of testing the most advanced weapon systems and components as well as the complexities of testing “systems of systems.”

Gehrig participates in Small Arms Testing at Aberdeen Proving Ground, Md., 1999.



Gehrig (left) during F-22 testing at Edwards Air Force Base, Calif., 1998.

ment in ensuring the success of the ongoing “transformation” of the Department as reflected in DoD’s *Revolution in Military Affairs* and the *Revolution in Business Affairs*.

A balanced workforce made up of sufficient numbers of people with appropriate skills is the foundation of the T&E infrastructure. T&E business processes build upon this foundation to enable testers to accomplish their mission in an efficient and effective manner. T&E facilities must be efficient and capable of providing the necessary data to an-

All of these components must work together in a seamless and integrated manner to provide the support so crucial to the acquisition process. The following discussion provides a more detailed look at each of these infrastructure elements.

#### People

The T&E professional workforce is the T&E community’s greatest asset and its biggest cost driver. During the 1990s, a significant percentage of DoD’s most valuable and experienced T&E personnel were lost to retirement or higher-paying employers. In addition, hiring

and promotion freezes, personnel draw-downs, contracting out, and limited funding made the hiring and promotion of outstanding, younger members of the workforce difficult. Consequently, the T&E community faces a major challenge in its ability to attract and retain the best and brightest of available technical experts.

Between fiscal 1990 and fiscal 2000, the Major Range and Test Facility Base (MRTFB) workforce was reduced by approximately 5,100 people (31 percent) while workload remained steady. This reduction is roughly equivalent to the reduction in workforce caused by four base closures. While some of these reductions were made possible by investments that enhanced efficiency, allowing facilities to operate with fewer people, many resulted in a loss of capability at our T&E centers.

We have also seen a 30 percent decrease in the number of military personnel at MRTFB activities since fiscal 1990. While the migration of military personnel back to combat units contributes to today’s readiness, the loss of military personnel from the T&E community will have an unintended and undesirable long-term effect on the ability of T&E to support the acquisition of future weapon systems that contribute to tomorrow’s readiness.

These problems are not limited to the government workforce. The contractor workforce has also been significantly cut. Since 1990, over 4,300 contractor jobs have been eliminated at MRTFB activities alone. Our contractors are also facing similar problems retaining and hiring employees. For example, the Atlantic Undersea Test and Evaluation Center has experienced an attrition rate between 20 and 40 percent among its contractor workforce in recent years. This attrition rate is in response to funding cuts aimed at reducing cost, quality-of-life issues, and long-term career concerns.

The T&E community also shares the Federal Government’s overall problem of an aging workforce. Since fiscal 1990,

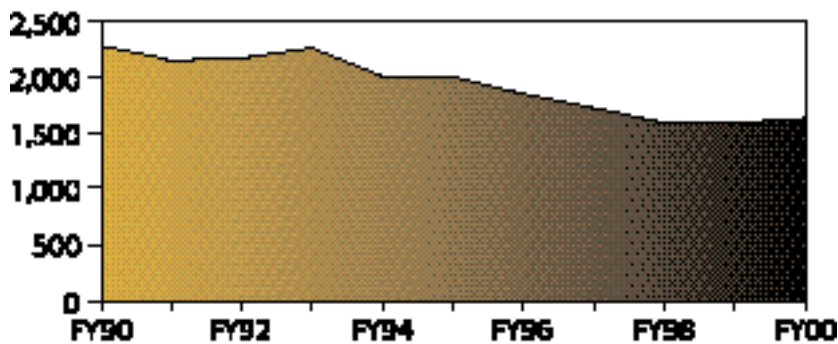
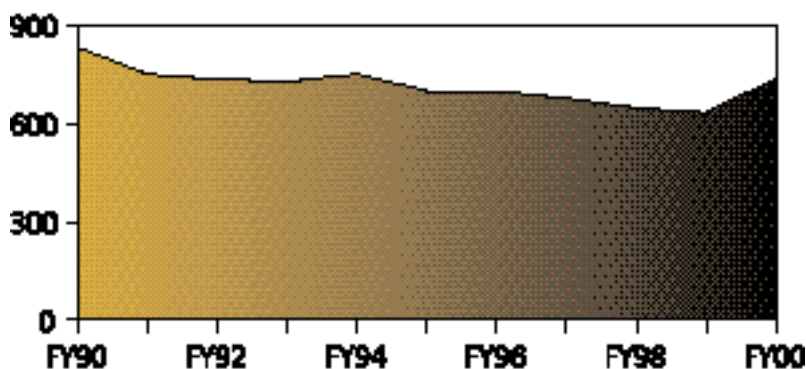


FIGURE 1. T&E Infrastructure Funding (Constant Fiscal 2001 \$M)

FIGURE 2. T&E Investment Funding (Constant \$M)



the number of Operational Test Activity civilian professionals (GS-12 through GS-15) in the 45 to 60 age bracket has increased from just over 50 percent in fiscal 1990 to nearly 65 percent in fiscal 1998. Civilian professionals under age 45, who had constituted about 45 percent of the professional workforce in fiscal 1990, now account for fewer than 30 percent.

Finally, the T&E workforce has experienced a gradual degradation of technical skills relative to the leading edge of technology over the past decade. This decline can be attributed to the retirement of the more experienced T&E workforce and the extremely limited infusion of recent college graduates trained in state-of-the-art technology and techniques.

#### Processes

The T&E community has struggled to offset limitations in manpower and facilities through business process reengineering, and has done a tremendous job of streamlining processes through:

- leveraging technology to improve the efficiency and productivity of our facilities;
- partnering with other government agencies, industry, and our allies to leverage each others' facilities; and
- reengineering our business processes to improve performance and provide more affordable testing through better business practices.

However, a decade of reductions and reengineering with limited investment in facilities has brought the T&E community to a point where it can no longer offset limitations by further business process reengineering initiatives alone.

#### Facilities

The last decade has seen a significant deterioration in the facilities at our test ranges. The average age of T&E facilities is now well over 40 years, and more than two-thirds of them are over 30 years old.

During the last 20 years, DoD's investment rate for T&E facilities has been less than one-third the rate of invest-

ment in private industry on an order of magnitude below the investment rate for high-technology industries. Military Construction funding for T&E facilities at the MRTFBs is down 76 percent since 1990. Our current investment level for Military Construction equates to a replacement rate of 500 years compared to industry rates of 20 to 40 years. Overall, investment funding is down by 10 percent since fiscal 1990.

#### State of T&E Funding

With downsizing and reduction, funding for infrastructure has been viewed as less important than funding for weapon system procurement. Infrastructure, in general, is considered to be part of the "tail," not part of the "teeth" of the fighting force. In fact, T&E infrastructure is far from the "tail." T&E, along with military training, is what sharpens the teeth and keeps them sharp. T&E is also how we know how sharp the "teeth" really are. In the desire to increase the "tooth to tail" ratio, T&E infrastructure modernization and funding continue to suffer.

The effects of T&E resource shortfalls are becoming increasingly acute. Obsolete facilities and equipment increasingly fall short of data collection requirements. The T&E infrastructure—its people, processes, and facilities—is under great stress.

Figures 1 and 2 help to illustrate the root cause of today's T&E shortfalls. The T&E infrastructure funding has dropped 28 percent, and the T&E investment funding has dropped 10 percent below the fiscal 1990 level as of fiscal 2000. These decreasing funding trends are exacerbated by the fact that T&E did not share in the build-up of Research, Development, Test and Evaluation (RDT&E) that peaked in the late 1980s.

The ongoing military transformation requires the T&E community to be prepared to test more sophisticated systems employing more advanced technology. Without the resources and funding required to sustain, maintain, and modernize T&E, we face the inescapable conclusion that T&E will reach a point

in the foreseeable future where the quality of testing and the information provided will deteriorate below reasonable and acceptable limits.

The ongoing military transformation is also changing the emphasis in military operations to interoperability, systems-of-systems, and information systems. As a result, systems can no longer be tested only in a stand-alone configuration but must be tested with multiple other systems, thereby increasing the complexity of the tests and straining the capabilities of existing facilities. Meeting these challenges will require new investment in T&E capabilities and facilities to ensure the T&E community is prepared to support our nation's defense readiness.

#### Lessons Learned in Reengineering Army T&E

A historical look at the evolution of T&E in the Army over the last 40 years provides a spectrum of opportunities and pitfalls that must be critically evaluated in formulating a cost-effective path for the future.

#### Organizational Evolution

The major reorganization of the Army in 1962 took the fragmented and proliferating T&E assets in the Army and consolidated them into a single command, namely the Army Test and Evaluation Command. In August 1962 and continuing over the next eight years, a collection of 44 organizations and 24,500 personnel was streamlined into 15 organizations and 14,000 personnel. Most of this consolidation was accomplished by 1966.

In the early 1970s, the Army Operational Test and Evaluation Agency was created to be the independent operational tester and evaluator.

#### T&E Reengineering

In fiscal 1995, the Army initiated a T&E reengineering study of Army T&E *using classic reengineering techniques that looked at process rather than organization*. The end result, however, is the basis for the Army decision process that by fiscal 1999, reconfigured the Army T&E as-

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sets into a single command—the Army Test Command.

The following discussion highlights the critical steps in the study team deliberations that were essential in evolving a reengineered T&E process. The study participants were veterans at realignment and consolidation studies in Army T&E. This reengineering exercise demanded that each member of the study team take an introspective look at a new process—a process devoid of the organizational policy and practices that each brought to the table. Yet each member had fundamental and detailed knowledge of the T&E process and under-

stood how it integrated into the materiel acquisition process.

In retrospect, when examining the reengineering end product and the steps to its development, it seems now to be a routine exercise. *Classic reengineering techniques were employed*, but developing the rapport and mutual understanding absolutely necessary for thorough process development, based upon each study team member's experience, was anything but routine.

The following discussion briefly describes the players, the problem, the vision, the traditional and reengineered processes, the decision levels in implementation, and the Army incremental decisions.

#### THE PLAYERS

In view of the T&E evolution described previously, the study team required members from a number of organizations. The members included T&E professionals from all walks of the Army T&E community:

- the operational evaluator;
- the operational tester;
- the developmental evaluator (multiple, since the mission was fragmented by materiel system designation);
- the Army Research Laboratory testers and evaluators (multiple);
- the Research, Development and Engineering Centers (evaluation support to the Program Managers/Program Executive Officers, and selected in-house test capabilities);
- the test instrumentation Program Manager (PM for the procurement of major instrumentation, targets, and threat simulators);
- the Training and Doctrine Command (requirements generator for new materiel acquisition systems); and
- Headquarters Department of the Army.

#### THE PROBLEM

Classic reengineering requires a statement of the problem. In simplest terms, the T&E customer perceived that testing was too expensive, and did not maximize value added to the program. Con-

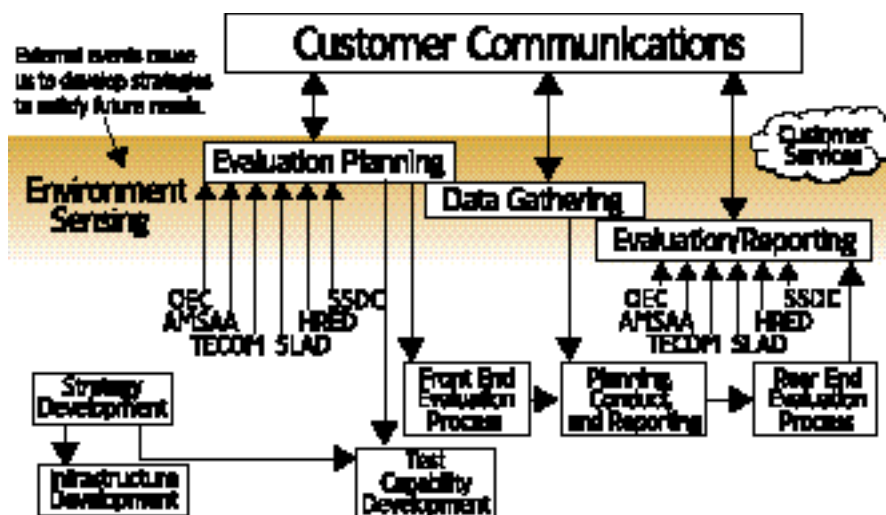
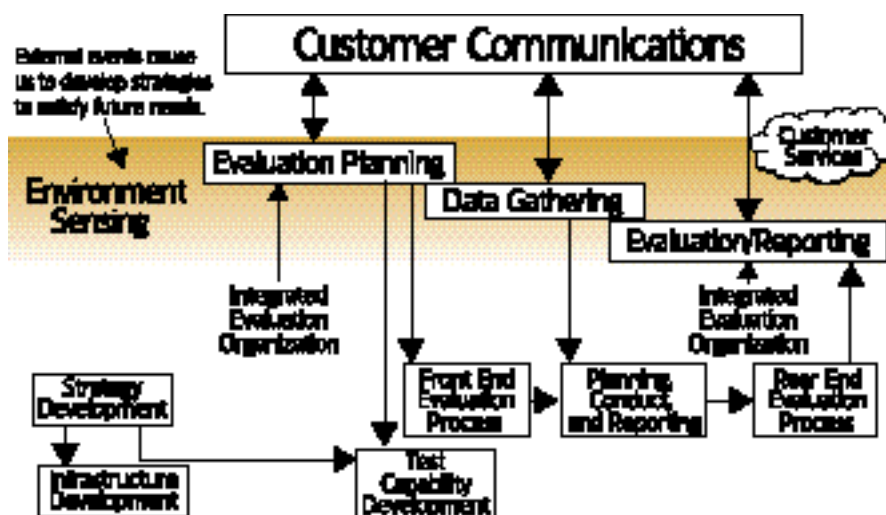


FIGURE 3. T&E—Traditional Process

FIGURE 4. T&E—Reengineered Process



sequently, the customer was eliminating testing, going to other sources for testing, and in some cases, creating similar and redundant test capabilities. The symptoms of the current process shortfalls were:

- multiple T&E planning documents;
- multiple independent tests; and
- multiple (maybe conflicting) reports.

Success criteria for reengineering T&E were established to assess how well these symptoms could be resolved by process improvements and organizational alternatives. Selected major criteria included:

- a simple flexible process;
- an integrated evaluation objective;

- integrated data collection
- reduction of organizational barriers;
- clearly defined links to technology and the requirements generation process; and
- appropriate T&E infrastructure.

#### THE REENGINEERING VISION

The study team vision embodied three basic concepts.

- First, that the T&E community's services are valued and sought by the customer.
- Second, that the T&E community actions are characterized as: 1) employing a disciplined yet flexible process, (2) embodying teamwork, (3) exuding mutual trust and common sense, 4) maximizing information

sharing, and 5) controlled by an appropriate level of oversight.

- The third vision concept requirement was that the process be robust, responsive, and efficient, providing critical information using a balance of modeling and simulation, experimentation, and testing and analysis in support of: 1) requirements generation, 2) system development, and 3) decision making at all levels.

#### THE TRADITIONAL T&E PROCESS

Figure 3 scopes the traditional process. The three major steps in the T&E process are:

- evaluation planning (what data do I need to prove or disprove my hypothesis;
- data gathering (historical data, testing, modeling) in response to the planning documentation; and
- analyzing and reporting or documenting the results (assessment of the system capability against requirements and issues).

Although the process shown in Figure 3 looks simplistic and intuitive, in retrospect it was not so when the paper was blank. The interaction of the diverse team members, each one expounding upon his or her particular slice of the pie, crystallized this schematic to one where each could accurately identify his or her process and products.

Looking at the many evaluation elements depicted in Figure 3, the most evident factor is that there are multiple players, and integration is not mandated by the policies/procedures that assigned these organizations their mission responsibilities. This is particularly important when one realizes that it is the evaluator who scopes the data requirements and consequently scopes the workload of the data-gathering element. This is significant since the data-gathering element is the cost driver for this process.

This concept is no surprise. In fact, this shortfall has been identified in the past and is best depicted in the findings of a 1984 Government Accounting Office

report to the Army. That report found three significant shortfalls:

- Each evaluation organization looks at only part of the system under test.
- Fragmented evaluation fails to disclose the collective impact of overall system deficiencies.
- The Army needs to integrate and interpret findings. This problem clearly has been overcome on selected systems over the last 25 years but *not* in a systematic manner.

Another factor that is embodied in Figure 3 is the lack of a single face to the customer. The customer (traditionally the Program Manager/Program Executive Officer) is often confronted with multiple independent demands to fund the data requirements generated by the independent evaluations. They often receive reports that provide conflicting statements of system capabilities, which are triggered by the current compartmented and fragmented evaluations that are mandated by policy.

The following discussion focuses on the redesigned T&E process. The testing concept is the same in both Figures 3 and 4, although the drivers are substantially different.

### THE REENGINEERED T&E PROCESS

The reengineered T&E process is depicted in Figure 4. From the evaluation perspective, the basic change was to create an integrated evaluation process from the fragmented evaluation responsibilities that currently existed. This new process set the stage for an integrated evaluation plan and report. Once this process was defined and understood, the plan to create an organization to execute the process was developed. This provided a single face to the customer, simplified the interface and products to the customer, and streamlined the data requirements placed upon the test organizations, thereby reducing the overall test cost and time to the customer.

From a test organization perspective, the major benefit derived from the reengineered process was the creation of an integrated strategy for the development and

maintenance of the test instrumentation and range infrastructure necessary to support the materiel acquisition process in a timely manner. The flexibility afforded by having a single organization to plan and prioritize the infrastructure investments overcame a major roadblock in the current fragmented funding allocation process. Integration of the Army testing assets within a single command allowed cost-effective realignment of capabilities over time.

### Implementing Options

One of the major stumbling blocks in any change to current operations is the cost and disruption caused during transition. To soften the impact of this transition, the Army employed three implementing stages in reengineering its T&E assets.

- The first stage, *functional realignment*, assigned and realigned specific functions within the existing organizational structures.
- The second stage, *organizational realignment*, combined organizationally but allowed organizations to remain at current locations.
- The third stage, *physical move* (not yet fully implemented), combines organizationally and consolidates at appropriate locations.

### A NEW ORGANIZATION

The Vice Chief of Staff of the Army approved the reengineering of Army evaluation assets and implemented a functional consolidation on Feb. 29, 1996. Subsequently, on June 12, 1996, the Vice Chief of Staff of the Army approved a realignment of several Army Materiel Command organizational elements into the Operational Test and Evaluation Command. The realigned organizational elements included: the Army Materiel Systems Analysis Agency, the Test and Evaluation Command, and the Army Research Laboratory Survivability/Lethality/Analysis Directorate.

The new organization, renamed the Army Evaluation Command, became operational on Oct. 1, 1996. Although the personnel relocation (the third implementation stage, has not yet been

fully implemented, on Oct. 1, 1998, the Army officially stood up the Army Test and Evaluation Command. This command comprises the Developmental Test Command (formerly the Test and Evaluation Command less the garrison function at Aberdeen Proving Ground), the Operational Test Command (formerly Test and Experimentation Command), and the Army Evaluation Command.

### The Future

The T&E downsizing and organizational consolidation lessons learned by the Army could serve as a barometer to evaluate other T&E assets in DoD. The Navy and the Air Force have undergone comparable reductions to the Army and are also at or below core capability levels. Army reengineering lessons learned may provide additional avenues of study for these Services. As integration has been demonstrated to be a key ingredient in the Army's T&E Reengineering process, an integrated effort of all of DoD T&E assets may hold the promise of maintaining core capabilities at affordable resource levels.

### Critical Attributes for a Viable Test Range Complex

In the pursuit of a single measure of goodness, we often create a concept that seems a reasonable descriptor, but falls woefully short when the implications of its controlling elements are examined. A prime example is using the measure of capacity as the primary decision-making criterion for the DoD test range complex, specifically during the Base Realignment and Closure studies of the 1990s.

Historically, this measure has attempted to reduce the decision to a simple equation that says: "How much work was accomplished in a prior historical period (typically the last five years) vs. how much workload is projected for a future time period." This approach leads to arriving at an incorrect conclusion: that as soon as workload declines, excess capacity has occurred and, therefore, downsizing is in order.

The underlying reason for this incorrect conclusion is basically that some capa-

bilities must be maintained even though they may lie dormant for extended periods of time. Correspondingly, a valid basic set of criteria for evaluating needed capability has not been used, or even developed. We have failed to properly evaluate the critical conditions that must exist to allow specific workload to be accomplished in the first place. The five critical conditions, or parameters, that define the test space are: 1) geography, 2) climate, 3) control of the environment, 4) extendibility of the test space, and 5) facilitization and skill base.

The parameter facilitization and skill base includes the essential people, processes, and facilities to conduct the test. More specifically, these capabilities can include instrumentation, support facilities, test processes, and the skilled people to conduct proper testing.

Consider a construct for a viable DoD test range complex that encompasses the preceding five parameters. The first four are anchor criteria, representative of those reasons that DoD sites were initially selected for testing. The fifth criterion is controllable in that facilities can be developed or expanded and people can be recruited or trained.

### **GEOGRAPHY**

Geography considers the air, land, sea and space at a given site. Many of the DoD ranges were established to take advantage of unique areas with geographical features not readily available elsewhere. Specific criteria relate to the volume and character of physical space, i.e., land and sea surface/subsurface area as well as the air space above that surface that provides opportunity to conduct unconstrained operations for development and operational testing and training in a realistic natural, open-air environment.

Factors contributing to good geography would include unique land masses/formations, such as mountains or islands that accrue directly to test utility and the physical size of the schedulable test volume that encompasses footprint lengths and widths, extent of elevation, and depth of water.

### **CLIMATE**

The parameter of climate considers the total collection of atmospheric conditions such as temperature, humidity, wind, visibility (fog/clouds/salt spray/dust) and precipitation, as well as their impact on facility requirements that allow the routine conduct of operations. A positive climate is one that does not adversely affect normal operations on an open range but also possesses desired climatic conditions to exercise specific envelopes of a test item.

### **CONTROL OF THE TEST SPACE**

This is a parameter that allows assessment of the degree to which the physical, electronic, and safety devices are in place and operational. This control ensures that test operations will be conducted in a secure environment without interference or concern for personnel or objects foreign to the test operation. Consideration must be given to encroachment and the special relationships and agreements specific ranges have made with local, state, and federal authorities. Also to be taken into consideration are established commercial air and surface traffic periodicity, density, and projected growth.

### **EXTENDIBILITY OF THE TEST SPACE**

The ability to extend the test space is also a critical parameter to future operations. Many of DoD's ranges have made special arrangements that have permitted the range to conduct inter-range scenarios where large extended footprints were critical to the test, but usually these arrangements have been developed for specific tests and projects. This parameter considers the ease to which these arrangements may be institutionalized to accommodate Joint Warfare exercises and broader missions or handle increased performance of systems.

Specific parameters of interest include the degree to which either the adjacent area to a range is accessible for use or the proximity to other range areas to conduct operations. Ease of extendibility should consider demonstrated surface or air inter-range operations that extend the test scenario and the inter-range control and simulation linkages.

### **FACILITIZATION AND SKILL BASE**

This final parameter, or critical attribute, to a viable test range complex is controllable with proper funding and management. It measures:

- the degree to which physical space is instrumented to control and record accurately and timely the critical performance data of an operation;
- the degree to which a site/course/impact area is properly prepared and maintained for conducting and operating a test;
- the adequacy of the test support facilities for pre-test preparation and post-test analysis;
- the in-place processes necessary to conduct test operations; and
- the extent of expertise available to execute test operations.

*This attribute represents the most flexible of the parameters in that it can be enhanced with the infusion of resources (dollars and people).*

### **Adapting to the Technology Drivers**

As technology drives the sophistication of weapon systems, the DoD test range complex of the future must adapt to the technology drivers. *The measure of capacity should not be a decision-making criterion and is inappropriate for treating these technology drivers.*

The preceding five attributes are the critical mechanisms that must be foremost in the decision process to shape DoD's future range complex. The Department must preserve, maintain, and protect those assets that are irreplaceable and foster their growth and development through modernization to support the testing demands of the future.

**Editor's Note:** The authors welcome questions or comments on this article. Contact them at [john.Gehrig@osd.mil](mailto:john.Gehrig@osd.mil), [gholloway@vzavenue.net](mailto:gholloway@vzavenue.net), or [geosmarm@worldnet.att.net](mailto:geosmarm@worldnet.att.net). For those readers interested in reading the second part of this article, watch for "Reflections on Test and Evaluation" in the September-October 2002 issue of *Program Manager*.